MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

DCA5068 – FIELD THEORY

(Diploma in Electronic Engineering)

6 MARCH 2020
3.00 p.m - 5.00 p.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 4 pages excluding the cover page with 4 Questions only.

2. Attempt **ALL (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Given vectors $\vec{A} = \hat{x} + 3\hat{y} - 2\hat{z}$ and $\vec{B} = 2\hat{x} - 3\hat{y}$, determine

(i) unit vector, $\hat{a}$
(ii) $\hat{y} \times \vec{B}$
(iii) $(\vec{A} \times \hat{y}) \cdot \hat{z}$ [3 × 3 marks]

(b) Convert the coordinates of the following points from Cylindrical to Cartesian coordinates:

(i) A(2, 0, 0)
(ii) B(3, π, 2) [2 × 3 marks]

(c) Find the surface area of an object covered by $R = 2;\ 0 \leq \theta \leq \pi/3;\ 0 \leq \phi \leq \pi,$ in spherical coordinate system. [6 marks]

(d) Given vectors $\vec{E} = 2\hat{x} - 3\hat{y} + \hat{z}$, $\vec{B} = 2\hat{x} - \hat{y} + 3\hat{z}$ and $\vec{P} = 4\hat{x} + 2\hat{y} - 2\hat{z}$. Show that $\vec{P}$ is perpendicular to both $\vec{E}$ and $\vec{B}$. [4 marks]

Question 2

(a) A charge $+q$ and a charge $-q$ are placed at opposite corners of a square. Will a third point charge experience a greater force if it is placed (i) at one of the empty corners of the square or (ii) at the center of the square? Explain. [3 marks]

(b) The attractive electrostatic force between the point charges $+8.44 \times 10^{-6}$ C and Q has a magnitude of 0.975 N when the separation between the charges is 1.31 m. Find the sign and magnitude of the charge Q. [5 marks]

(c)(i) Charge q_1 is inside a Gaussian surface; charge q_2 is just outside the surface. Does the electric flux through the surface depend on q_1? Does it depend on q_2? Explain. [3 marks]

(ii) A surface encloses the charges q_1 = 3.2 μC, q_2 = 6.9 μC and q_3 = –4.1 μC. Find the electric flux, Φ through this surface. [3 marks]

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Question 2

(d)(i) A uniform electric field of magnitude 6.1×10^5 N/C points in the positive x-direction. Find the change in electric potential, V between the origin and the points (I) (0, 6.0 m) and (II) (6.0 m, 0). [2 × 2 marks]

(ii) A charge of –2.205 μC is located at (3.055 m, 4.501 m), and a charge of 1.800 μC is located at (–2.533 m, 0). Find the electric potential, V at the origin. [4 marks]

(e) A parallel-plate capacitor is connected to a battery that maintains a constant potential difference V between the plates. If a dielectric is inserted between the plates of the capacitor, do the following quantities increase, decrease, or remain the same? (i) Electric field between the plates, (ii) charge on the plates and (iii) capacitance in the capacitor. [3 marks]

Question 3

(a) Describe how the motion of a charged particle can be used to distinguish between an electric and a magnetic field. [3 marks]

(b) The magnetic force exerted on a 1.2 m segment of straight wire is 1.6 N. The wire carries a current of 3.0 A in a region with a constant magnetic field of 0.50 T. What is the angle between the wire and the magnetic field? [5 marks]

(c)(i) The number of turns per meter in a solenoid of fixed length is doubled. At the same time the current in the solenoid is halved. Does the energy stored in the inductor increase, decrease, or stay the same? Explain. [3 marks]

(ii) The maximum current in a superconducting solenoid can be as large as 3.75 kA. If the number of turns per meter in such a solenoid is 3250, what is the magnitude of the magnetic field, B it produces? [5 marks]

(d) A 0.25 T magnetic field is perpendicular to a circular loop of wire with 50 turns and a radius of 15 cm. If the magnetic field is reduced to zero in 0.12 s, what is the magnitude of the induced emf? [5 marks]

(e) Explain the difference between a magnetic field and a magnetic flux. [4 marks]

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Question 4

(a) A step-down transformer produces a voltage of 6 V across the secondary coil when the voltage across the primary coil is 120 V. What voltage appears across the primary coil of this transformer if 120 V is applied to the secondary coil? [4 marks]

(b)(i) Explain the diamagnetism in magnetic materials. [3 marks]

(ii) Give the relative permeability, μ_r and magnetic susceptibility, χ_m values of diamagnetic material. [4 marks]

(c)(i) Write an expression of Ohm's law for the magnetic equivalent circuit. [2 marks]

(ii) Explain the reluctance in a magnetic circuit. [3 marks]

(d) A magnet circuit of 100 turns is shown in Figure Q4. The length of the air gap is 0.001 m. The cross sectional area is 0.002 m^2 and the relative permeability of the magnetic material is 1000.

(i) Draw an equivalent circuit for Figure Q4. [3 marks]

(ii) Calculate the flux density, B of the magnetic circuit if the fringing effect is negligible when a current of 3 A flows in the coil. [6 marks]

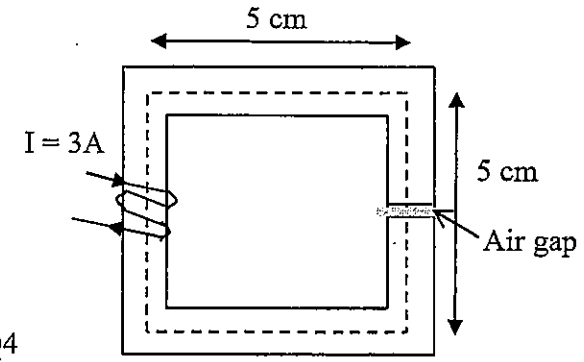

Figure Q4

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FORMULAE

Transformation	Coordinate Variables	Unit Vectors	Vector Components
Cartesian to Cylindrical	$r=\sqrt{x^2+y^2}$ $\phi=\tan^{-1}(y/x)$ $z=z$	$\hat{r}=\hat{x}\cos\phi+\hat{y}\sin\phi$ $\hat{\phi}=-\hat{x}\sin\phi+\hat{y}\cos\phi$ $\hat{z}=\hat{z}$	$A_r=A_x\cos\phi+A_y\sin\phi$ $A_\phi=-A_x\sin\phi+A_y\cos\phi$ $A_z=A_z$
Cylindrical to Cartesian	$x=r\cos\phi$ $y=r\sin\phi$ $z=z$	$\hat{x}=\hat{r}\cos\phi-\hat{\phi}\sin\phi$ $\hat{y}=\hat{r}\sin\phi+\hat{\phi}\cos\phi$ $\hat{z}=\hat{z}$	$A_x=A_r\cos\phi-A_\phi\sin\phi$ $A_y=A_r\sin\phi+A_\phi\cos\phi$ $A_z=A_z$
Cartesian to Spherical	$R=\sqrt{x^2+y^2+z^2}$ $\theta=\tan^{-1}(\sqrt{x^2+y^2}/z)$ $\phi=\tan^{-1}(y/x)$	$\hat{R}=\hat{x}\sin\theta\cos\phi$ $+\hat{y}\sin\theta\sin\phi+\hat{z}\cos\theta$ $\hat{\theta}=\hat{x}\cos\theta\cos\phi$ $+\hat{y}\cos\theta\sin\phi-\hat{z}\sin\theta$ $\hat{\phi}=-\hat{x}\sin\phi+\hat{y}\cos\phi$	$A_R=A_x\sin\theta\cos\phi$ $+A_y\sin\theta\sin\phi+A_z\cos\theta$ $A_\theta=A_x\cos\theta\cos\phi$ $+A_y\cos\theta\sin\phi-A_z\sin\theta$ $A_\phi=-A_x\sin\phi+A_y\cos\phi$
Spherical to Cartesian	$x=R\sin\theta\cos\phi$ $y=R\sin\theta\sin\phi$ $z=R\cos\theta$	$\hat{x}=\hat{R}\sin\theta\cos\phi$ $+\hat{\theta}\cos\theta\cos\phi-\hat{\phi}\sin\phi$ $\hat{y}=\hat{R}\sin\theta\sin\phi$ $+\hat{\theta}\cos\theta\sin\phi+\hat{\phi}\cos\phi$ $\hat{z}=\hat{R}\cos\theta-\hat{\theta}\sin\theta$	$A_x=A_R\sin\theta\cos\phi$ $+A_\theta\cos\theta\cos\phi-A_\phi\sin\phi$ $A_y=A_R\sin\theta\sin\phi$ $+A_\theta\cos\theta\sin\phi+A_\phi\cos\phi$ $A_z=A_R\cos\theta-A_\theta\sin\theta$
Cylindrical to Spherical	$R=\sqrt{r^2+z^2}$ $\theta=\tan^{-1}(r/z)$ $\phi=\phi$	$\hat{R}=\hat{r}\sin\theta+\hat{z}\cos\theta$ $\hat{\theta}=\hat{r}\cos\theta-\hat{z}\sin\theta$ $\hat{\phi}=\hat{\phi}$	$A_R=A_r\sin\theta+A_z\cos\theta$ $A_\theta=A_r\cos\theta-A_z\sin\theta$ $A_\phi=A_\phi$
Spherical to Cylindrical	$r=R\sin\theta$ $\phi=\phi$ $z=R\cos\theta$	$\hat{r}=\hat{R}\sin\theta+\hat{\theta}\cos\theta$ $\hat{\phi}=\hat{\phi}$ $\hat{z}=\hat{R}\cos\theta-\hat{\theta}\sin\theta$	$A_r=A_R\sin\theta+A_\theta\cos\theta$ $A_\phi=A_\phi$ $A_z=A_R\cos\theta-A_\theta\sin\theta$

Permittivity of free space, $\varepsilon_o=8.854\times10^{-12}\,F/m$

Permeability of free space, $\mu_o=4\pi\times10^{-7}\,T.m/A$

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